CLAIMS

What is claimed is:

1. An MRAM cell comprising:
   a magnetic tunneling junction including
      a free layer,
      a pinned layer, and
      a spacer layer disposed between the free layer and the pinned layer;
   a digit line including a bit line segment disposed proximate to the magnetic tunneling junction;
   a bit line including a bit line segment in electrical contact with the magnetic tunneling junction; and
   a magnetic liner layer disposed around the bit line segment and contacting the free layer.

2. The MRAM cell of claim 1 wherein the digit line segment is disposed proximate to the pinned layer and the bit line segment is in electrical contact with the free layer.

3. The MRAM cell of claim 1 wherein the bit line segment is disposed proximate to the pinned layer and the digit line segment is in electrical contact with the free layer.

4. The MRAM cell of claim 1 wherein the magnetic liner layer is electrically conductive.

5. The MRAM cell of claim 1 wherein the bit and digit lines are formed of a metal selected from the group consisting of Cu, W, and Al.

6. The MRAM cell of claim 1 further including an antiferromagnetic layer disposed adjacent to the pinned layer.

7. The MRAM cell of claim 1 wherein the magnetic liner layer is formed of Permalloy.

8. The MRAM cell of claim 7 wherein the Permalloy is between 16 and 22 atomic percent iron.

9. The MRAM cell of claim 7 wherein the Permalloy is $Ni_{81}Fe_{19}$.

10. The MRAM cell of claim 1 wherein the magnetic liner layer has a thickness of about 20Å to about 500Å.

11. The MRAM cell of claim 1 wherein the magnetic liner layer has a thickness of about 30Å to about 100Å.

12. The MRAM cell of claim 1 wherein the magnetic liner layer is formed of a material selected from the group consisting of CoZrCr, CoZrNb, CoZrRe, FeSiAl, FeN, FeAlN, FeRhN, and FeTaN.

13. The MRAM cell of claim 1 wherein the pinned layer is two ferromagnetic layers separated by a spacer layer.

14. The MRAM cell of claim 1 wherein the free layer is two ferromagnetic layers.

15. An MRAM cell comprising:

a magnetic tunneling junction including

a free layer having a magnetization orientation,

a pinned layer, and

an insulating spacer layer disposed between the free layer and the pinned layer;

a digit line including a segment disposed proximate to the pinned layer;

a bit line including a segment in electrical contact with the free layer;

a magnetic liner layer disposed around the bit line segment and contacting the free layer such that a magnetic field encircles the bit line segment.

16. The MRAM cell of claim 15 wherein the magnetic liner layer is electrically conductive.

17. The MRAM cell of claim 15 wherein the bit and digit lines are formed of a metal selected from the group consisting of Cu, W, and Al.

18. The MRAM cell of claim 15 further including an antiferromagnetic layer disposed adjacent to the pinned layer.

19. The MRAM cell of claim 15 wherein the magnetic liner layer is formed of Permalloy.

20. The MRAM cell of claim 19 wherein the Permalloy is between 16 and 22 atomic percent iron.

21. The MRAM cell of claim 19 wherein the Permalloy is $Ni_{81}Fe_{19}$.

22. The MRAM cell of claim 15 wherein the magnetic liner layer has a thickness of about 20Å to about 500Å.

23. The MRAM cell of claim 15 wherein the magnetic liner layer has a thickness of about 30Å to about 100Å.

24. The MRAM cell of claim 15 wherein the pinned layer is two ferromagnetic layers separated by a spacer layer.

25. The MRAM cell of claim 15 wherein the free layer is two ferromagnetic layers.

26. An MRAM cell comprising:

a magnetic tunneling junction including

a free layer,

a pinned layer, and

an insulating spacer layer disposed between the free layer and the pinned layer;

a digit line including a segment disposed proximate to the pinned layer, the digit line segment having a long axis defining a first direction;

an electrically insulating spacer layer disposed between the digit line segment and the pinned layer;

a bit line including a segment in electrical contact with the free layer, the bit line segment having a long axis defining a second direction substantially perpendicular to the first direction;

a magnetic liner layer disposed around the bit line segment and contacting the free layer.

27. The MRAM cell of claim 26 wherein the magnetic liner layer is electrically conductive.

28. The MRAM cell of claim 26 wherein the bit and digit lines are formed of a metal selected from the group consisting of Cu, W, and Al.

29. The MRAM cell of claim 26 further including an antiferromagnetic layer disposed adjacent to the pinned layer.

30. The MRAM cell of claim 26 wherein the magnetic liner layer is formed of Permalloy.

31. The MRAM cell of claim 30 wherein the Permalloy is between 16 and 22 atomic percent iron.

32. The MRAM cell of claim 30 wherein the Permalloy is $Ni_{81}Fe_{19}$.

33. The MRAM cell of claim 26 wherein the magnetic liner layer has a thickness of about 20Å to about 500Å.

34. The MRAM cell of claim 26 wherein the magnetic liner layer has a thickness of about 30Å to about 100Å.

35. The MRAM cell of claim 26 wherein the pinned layer is two ferromagnetic layers separated by a spacer layer.

36. The MRAM cell of claim 26 wherein the free layer is two ferromagnetic layers.

37. An MRAM cell comprising:

a magnetic tunneling junction including

a free layer,

a pinned layer, and

an insulating spacer layer disposed between the free layer and the pinned layer;

a digit line including a segment disposed proximate to the pinned layer, the segment having a long axis defining a first direction;

a bit line including

a segment in electrical contact with the free layer and having

a long axis defining a second direction substantially perpendicular to the first direction,

a bottom surface abutting the free layer,

a top surface opposite the bottom surface, and

first and second vertical surfaces opposite one another and connecting the top and bottom surfaces; and

a magnetic liner layer disposed around the bit line segment and contacting the first and second vertical surfaces and the top surface.

38. The MRAM cell of claim 37 wherein the magnetic liner layer also contacts the free layer.

39. The MRAM cell of claim 37 wherein the magnetic liner layer is electrically conductive.

40. The MRAM cell of claim 37 wherein the bit and digit lines are formed of a metal selected from the group consisting of Cu, W, and Al.

41. The MRAM cell of claim 37 further including an antiferromagnetic layer disposed adjacent to the pinned layer.

42. The MRAM cell of claim 37 wherein the magnetic liner layer is formed of Permalloy.

43. The MRAM cell of claim 42 wherein the Permalloy is between 16 and 22 atomic percent iron.

44. The MRAM cell of claim 42 wherein the Permalloy is $Ni_{81}Fe_{19}$.

45. The MRAM cell of claim 37 wherein the magnetic liner layer has a thickness of about 20Å to about 500Å.

46. The MRAM cell of claim 37 wherein the magnetic liner layer has a thickness of about 30Å to about 100Å.

47. The MRAM cell of claim 37 wherein the pinned layer is two ferromagnetic layers separated by a spacer layer.

48. The MRAM cell of claim 37 wherein the free layer is two ferromagnetic layers.

49. An MRAM cell comprising:

a magnetic tunneling junction including

a free layer,

a pinned layer, and

an insulating spacer layer disposed between the free layer and the pinned layer;

a digit line including a segment disposed proximate to the pinned layer, the digit line segment having a long axis defining a first direction;

a bit line including a bit line segment in electrical contact with the free layer and having a long axis defining a second direction substantially perpendicular to the first direction; and

a magnetic sheath disposed around the bit line segment and formed from the free layer and a magnetic liner layer.

50. The MRAM cell of claim 49 wherein the magnetic liner layer is electrically conductive.

51. The MRAM cell of claim 49 wherein the bit and digit lines are formed of a metal selected from the group consisting of Cu, W, and Al.

52. The MRAM cell of claim 49 further including an antiferromagnetic layer disposed adjacent to the pinned layer.

53. The MRAM cell of claim 49 wherein the magnetic liner layer is formed of Permalloy.

54. The MRAM cell of claim 53 wherein the Permalloy is between 16 and 22 atomic percent iron.

55. The MRAM cell of claim 53 wherein the Permalloy is $Ni_{81}Fe_{19}$.

56. The MRAM cell of claim 49 wherein the magnetic liner layer has a thickness of about 20Å to about 500Å.

57. The MRAM cell of claim 49 wherein the magnetic liner layer has a thickness of about 30Å to about 100Å.

58. The MRAM cell of claim 49 wherein the pinned layer is two ferromagnetic layers separated by a spacer layer.

59. The MRAM cell of claim 49 wherein the free layer is two ferromagnetic layers.

60. A method of fabricating an MRAM cell comprising:

providing a substrate;

forming a digit line on the substrate;

forming an insulating spacer including a contact via over the bit line;

forming a bottom lead over the insulating spacer;

forming a magnetic tunnel junction stack over the bottom lead;

forming a first liner layer over the magnetic tunnel junction;

forming a bit line over the magnetic tunnel junction stack; and

forming a second liner layer over the bit line.

61. The method of claim 60 wherein forming the bit line includes

forming and patterning an oxide layer on the substrate;

depositing a conductive metal; and

planarizing a top surface of the conductive metal.

62. The method of claim 61 wherein the conductive metal is selected from the group consisting of copper, tungsten, and aluminum.

63. The method of claim 61 wherein planarizing is performed by CMP.

64. The method of claim 60 wherein forming the bottom lead is performed by depositing a conductive metal selected from the group consisting of copper, tungsten, and aluminum.

65. The method of claim 60 wherein forming the bottom lead includes a patterning step.

66. The method of claim 60 wherein forming the magnetic tunnel junction stack includes forming a first ferromagnetic layer over the bottom lead;
forming a tunneling barrier layer over the first ferromagnetic layer; and
forming a second ferromagnetic layer over the tunneling barrier layer.

67. The method of claim 66 wherein forming the magnetic tunnel junction stack further includes forming an antiferromagnetic layer between the first ferromagnetic layer and the bottom lead.

68. The method of claim 66 wherein forming the magnetic tunnel junction stack further includes forming an antiferromagnetic above the second ferromagnetic layer.

69. The method of claim 66 wherein forming the magnetic tunnel junction stack further includes a patterning step.

70. The method of claim 60 further comprising forming an insulating material layer over the insulating spacer.

71. The method of claim 70 wherein forming an insulating material layer includes forming a trench therein and over the magnetic tunnel junction stack.

72. The method of claim 71 wherein the trench has first and second sidewalls.

73. The method of claim 72 wherein the first liner layer is formed on the first and second sidewalls.

74. The method of claim 60 wherein the first liner layer is formed with a thickness in the range of about 20Å to about 500Å.

75. The method of claim 60 wherein the first liner layer is formed by ion beam deposition or physical vapor deposition.

76. The method of claim 60 wherein the first liner layer is formed of Permalloy.

77. The method of claim 60 further comprising forming a stop layer over the first liner layer.

78. The method of claim 77 further comprising forming a seed layer over the stop layer.

79. The method of claim 60 wherein forming the bit line includes forming a seed layer.

80. The method of claim 60 wherein the bit line is formed of a conductive metal selected from the group consisting of copper, tungsten, and aluminum.

81. The method of claim 60 wherein forming the bit line includes a planarization.

82. The method of claim 81 wherein forming the bit line includes an ion beam etch.

83. The method of claim 60 wherein forming the second liner layer includes

forming and patterning a mask; and

removing portions of the second liner layer.

84. The method of claim 60 wherein the second liner layer is formed with a thickness in the range of about 20Å to about 500Å.

85. The method of claim 60 wherein the second liner layer is formed of Permalloy.

86. A method of fabricating an MRAM cell comprising:

providing a digit line;

forming a magnetic tunnel junction stack over the digit line;

forming a bit line; and

forming a magnetic liner layer over the bit line and in contact with the magnetic tunnel junction stack.

87. The method of claim 86 wherein forming a magnetic tunnel junction stack includes forming a free ferromagnetic layer and wherein the magnetic liner layer is formed in contact with the free ferromagnetic layer.

88. A method of storing a bit of data in an MRAM cell, comprising:

pinning a magnetic orientation of a first ferromagnetic layer in a magnetic tunnel junction;

simultaneously generating

a first write current in a digit line including segment proximate to the magnetic tunnel junction and

a second write current in a bit line including segment proximate to the magnetic tunnel junction, the write currents being sufficient to produce a magnetic field capable of orienting a magnetic domain of a second ferromagnetic layer in the magnetic tunnel junction; and

maintaining the orientation of the magnetic field of the second ferromagnetic layer by creating a magnetic loop around the bit line.